Power Systems Development Facility Quarterly Technical Progress Report

**Quarterly Report
October 1 - December 31, 1996**

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POWER SYSTEMS DEVELOPMENT FACILITY
QUARTERLY TECHNICAL PROGRESS REPORT
OCTOBER 1 - DECEMBER 31, 1996

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1.0 INTRODUCTION AND SUMMARY

This quarterly technical progress report summarizes the work completed during the fourth quarter, October 1 through December 31, 1996, under the Department of Energy (DOE) Cooperative Agreement No. DE-FC21-90MC25140 entitled "Hot Gas Cleanup Test Facility for Gasification and Pressurized Combustion." The objective of this project, herein referred to as the Power Systems Development Facility (PSDF), is to evaluate hot gas particle control technologies using coal-derived gas streams. This project entails the design, construction, installation, and use of a flexible test facility which can operate under realistic gasification and combustion conditions. The major particulate control device (PCD) issues to be addressed include the integration of the PCDs into coal utilization systems, on-line cleaning techniques, chemical and thermal degradation of components, fatigue or structural failures, blinding, collection efficiency as a function of particle size, and scale-up of particulate control systems to commercial size.

During this quarter considerable effort was expended in finalizing drawings and technical information for bid packages in support of the Request for Quotation (RFQ) for the fixed-price construction of the Foster Wheeler train. The packages were finalized and released for bids from seven companies at the beginning of November. A prebid meeting was held in mid-November when representatives from the interested companies toured the site and sought clarification on certain issues. Six bids were received by the end of December. Discussions were also held with a number of labor brokers to provide construction support. Their bids are being evaluated in conjunction with those for the RFQ.

Work was resumed on the Allison gas turbine in November. Remaining design issues, the interfaces with the Multistage Annular Swirl Burner (MASB), along with the electrical drawings, and the turbine enclosure were addressed. The turbine is expected to be delivered the first week of January 1997.

Quotations were received for the metal-sleeved, refractory-lined pipe work and the expansion joints for the pipe line between the alkali getters and the MASB. Superior Hardsurfacing Company of Tulsa was selected to provide the lined pipe. The pipes and the expansion joints are expected to be delivered during May 1997.

Planning was begun to identify tasks and manpower requirements to support commissioning of the FW train. All plans need to be integrated with MWK activities to determine when effort is available to support commissioning.

In the Fourth Quarter there were four test runs with the M.W. Kellogg Transport Reactor process. During the first half of October, Test CCT2A was performed to demonstrate hot solids circulation with sand. Silica sand was used as starting bed material for the first time. In early

November, Test CCT2B was an unsuccessful attempt at coal combustion in early November due to coal feeding and startup burner problems. The most successful of the runs was the third, CCT2C (November 14-22), when the MWK Transport Reactor operated on coal for 146 hours. In summary, this characterization test run was started on 11/14 with Startup burner lit at 10:00. Until the Transport reactor train was taken off-line on 11/22 at 14:00, the following operational hours were realized: The Startup burner was on between 11/14 at 10:00 and 11/17 at 21:17 for 82 hours (83 min was lost due to trips); the cokebreeze and PRB coal mixture was batch fed between 11/15 20:30 and 11/16 07:20 for 9 hours and 20 minutes (100 minutes was lost due to trips); and the Alabama Bituminous coal was fed for 146 hours between 11/16 07:20 and 11/22 14:00 (4 hours and 40 minutes was lost due to trips). The fourth test, CCT3A, was performed in early December to evaluate the Disengager solids removal efficiency.

There were no significant problems with the PCD during any of the runs, in spite of particulate loadings well above design. All of the tests in this quarter used sand instead of alumina as the Transport Reactor bed material. This change in bed material caused a dramatic shift in the mean particle size of the ash collected from the PCD hopper. For example, during the August run the mean particle size ranged from 5-15 μm . However, unless dolomite was being fed into the Transport Reactor, the mean particle size of the material leaving the PCD during the November run ranged from 50-320 μm .

Operationally, the focus was on reliably measuring the ash level in the PCD solids outlet cone using the existing thermocouples to avoid filling the PCD with ash. Using a combination of instrumentation from the PCD and ash removal system, the operations staff was successful in keeping the PCD cone essentially empty of solids throughout all four runs.

Southern Research Institute (SRI) successfully commissioned the inlet batch sampling probe during the November coal run. In total they took four samples which measured the bulk loading to the PCD. The results from their samples were comparable to the particulate loading as determined from the load cells on the ash removal system.

With the exception of two Schumacher F40 candle filters supplied by Roger Chen at West Virginia University (WVU), all of the filter elements in the PCD are new elements manufactured by Pall. In the upper plenum there are 12 Pall 326 elements, 23 unused Pall 442T elements from Tidd and one of the Schumacher elements. In the bottom plenum there are 54 Pall 442T elements purchased by SCS and the other Schumacher element. No elements were removed for testing during the quarter.

It should be noted that this report includes accounts of progress made by Foster Wheeler (FW), M. W. Kellogg (MWK), Combustion Power Company (CPC), Industrial Filter & Pump (IF&P), Westinghouse, Southern Research Institute (SRI), and Southern Company Services (SCS).

2.0 PROGRESS REPORT OUTLINE

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The above outline contains the main topic headings presently projected for the current and subsequent quarterly technical progress reports. The following sections in this progress report contain only the status report for those areas of substantial importance to this reporting period. Therefore, not all the above headings may be reflected in this progress report. Also, the above outline may be modified as needs dictate in the future.

3.0 FOSTER WHEELER APFBC

3.1 ENGINEERING DESIGN

In support of the Request for Quotation (RFQ) for the fixed-price construction of the Foster Wheeler train, considerable effort was expended in finalizing drawings and technical information for the bid packages. The packages were finalized and released for bids from 7 companies at the beginning of November. A prebid meeting was held in mid-November when representatives from the interested companies toured the site and sought clarification on certain issues. Six bids were received by the end of December. These will be evaluated and a selection made in February. At present construction is most likely to start in May 1997. Also in November, discussions were held with a number of labor brokers to provide construction support. Their bids are being evaluated in conjunction with those for the RFQ. To minimize construction variance costs, the Intergraph model was updated to identify any potential pipework interferences with the structural steel.

Work was resumed on the Allison gas turbine in November. A meeting was held to discuss the remaining design issues. The interfaces with the Multistage Annular Swirl Burner (MASB) were discussed, along with the electrical drawings, and the turbine enclosure. The turbine is expected to be delivered the first week of January 1997. The enclosure will be delivered around March.

3.2 CONSTRUCTION

Quotations were received for the metal-sleeved, refractory-lined pipe work and the expansion joints for the pipe line between the alkali getters and the MASB. Superior Hardsurfacing Company of Tulsa was selected to provide the lined pipe. Meetings with the expansion joint bidders will be held in January. the pipes and the expansion joints are expected to be delivered during May 1997, which matches the proposed construction schedule.

3.3 COMMISSIONING

Operating procedures were written for the coarse and fine ash removal systems and the ash disposal system. In writing these procedures, a number of inconsistencies between the design for the FW discharge hoppers and the Clyde dense phase conveyors were identified and corrected. Work was started on preparing the functional checks for these equipment items in preparation for their commissioning.

Planning was begun to identify tasks and manpower requirements to support commissioning of the FW train. All plans need to be integrated with MWK activities to determine when effort is available to support commissioning. The major objective for the

FW process this year is to operate the Gas Turbine (GT) and MASB in simple cycle mode, burning propane. As the GT stands outside the main structure it can be worked on almost independently of construction activities within the structure. This needs to be fully operational before the circulating PFBC can be operated. Depending upon the construction schedule, much of the commissioning for the circulating PFBC is expected be completed in 1997.

4.0 M. W. KELLOGG TRANSPORT REACTOR PROCESS

4.1 TRANSPORT REACTOR OPERATION

During the beginning of the quarter, a newly fabricated reactor Startup Burner, BR0201, pilot assembly was installed. The deposits found in the reactor system after the August commissioning test run were cleaned. Due to the difficulty experienced in inspection and cleaning the various sections of the reactor, additional inspection ports and a flange near the top of the Riser were deemed necessary for safe maintenance without causing damage to the refractory.

4.1.1 Test Run CCT2A

Starting September 27, the Transport Reactor, RX0201, was leak tested at 310 psig; a few minor leaks were found, and selected bleeds were balanced at both 60 and 160 psig. On September 28, 1996, the HTF system, the Thermal Oxidizer, BR0401, and backpulsing of the PCD were started. On September 29 instrumentation problems with the Thermal Oxidizer slowed progress. The Primary Gas Cooler, HX0202, was cut in to pre-warm the PCD. The dense phase systems were run for ~ 20 minutes to check their operability. The reactor was depressurized, and the leaks were repaired.

On October 1, 1996, the reactor was leak tested at 310 psig, and no leaks were found. The seal on the Spent Solids Transporter System, FD0510, sphere valve was lost so the reactor system was shutdown to repair the valve. The following day the reactor system was again started, and all attempts made to light the Startup Burner pilot were unsuccessful. The flame rod was taken out, tested, and replaced. The BR0210 pilot was re-lit and the outlet temperature was held at 500°F for 6 hours. The Reactor J-leg aeration flow, FI681, was set so that the hot air from BR0201 would be forced through the Riser instead of preferentially flowing through the standpipe and out through the cyclone. This balanced the temperature in the reactor riser and standpipe. After the six hour hold, the main burner was lit and a 3 hour hold at 800 °F was started.

The burner exit temperature was then gradually increased to 1000 °F and held for 3 hours. Then the burner exit temperature was raised to 1200 °F at about 50 °F per hour and maintained for 8 hours. The Combustor Heat Exchanger J-leg aeration flow, FI680, and the reactor combustion air flow, FI201, were varied to induce hot air into the HX0203 J-leg, but neither worked. Finally FI230 was increased to use the compressor's hot air to heat HX0203. During startup and operations the skin temperatures were monitored closely.

On October 4, 17,325 pounds of sand was fed into the reactor. During the day, the Startup Burner tripped once but was relit by lowering the reactor pressure to 50 psig. Solid circulation was started and the reactor pressure was increased to 90 psig to reduce

riser velocity and maintain the burner firing rate. Approximately 3,300 pounds of additional sand was added into reactor. Around 07:30, the Startup Burner tripped, and the reactor system was shutdown. After replacing the burnt flame tip, the reactor system was started again. Attempts to relight the burner were unsuccessful; so, the reactor system was shutdown. When the BR0201 pilot assembly was pulled, the pilot nozzle was found to be plugged with rust from the propane line, and the burner eductor tube had slight burn marks.

On October 6, 1996, after the pilot nozzle had been cleaned, the reactor was started again and the pilot was relit. Flows were set to start reactor solids circulation, but BR0201 tripped again. The reactor system was shutdown after several unsuccessful attempts to relight the burner. During every attempt, the pilot lit, but the flame was not detected by the flame rod. On inspection, the tip of the flame rod was again found to have been burned out, making the flame rod shorter and out of the flame zone.

The problem of flame rod tip burnout was traced to inadequate cooling of the tip with the new pilot assembly that was installed at the start of CCT2A test run. In the old pilot assembly, a hole was drilled in the flame rod guide tube at the site to induce air and provide cooling to the flame rod tip. Apparently this cooling was sufficient and necessary to maintain the physical integrity of the tip. Due to uncertainty of the amount of inducted air for cooling, an external forced cooling purge was installed to provide the necessary cooling for the flame rod tip and prevent burnouts.

On October 13, auxiliary systems needed for Transport Reactor startup were put in service. The Startup Burner pilot was lit with the newly installed cooling purge to the flame rod tip. The burner was shutdown after two hours to visually inspect the flame rod tip. The flame rod had some discoloration on the tip which is about 6 inches long, but there were no signs of any burn marks. The burner was assembled, all systems were restarted, and the pilot was lit with reactor pressure set at 75 psig. About 3,000 pounds of sand was added to the reactor with a low carryover rate to the PCD.

On October 15, BR0201 was shutdown and the reactor was depressurized to 15 psig to blow out the plugged aeration nozzles. The pilot was lit, the reactor was gradually pressurized to 100 psig, and the main burner was lit. Solids circulation was then started. Another 1,500 pounds of sand was added to the reactor to maintain the inventory. The Thermal Oxidizer tripped causing momentary fluctuations in the propane flow from the vaporizer which then tripped BR0201. The reactor pressure was reduced to 60 psig, and BR0201 was started. FI680 was reduced to decrease the solids circulation rate, and thus, the solid carryover rate to the PCD. Another 1,400 pounds of solids was loaded into the reactor to make-up for the excessive carryover to the PCD. FIC230 and the HX0203 dilute phase pressure control valve, PDV384, positions were varied to evaluate their effect on solids carryover. The solids carryover seemed to be lessened with FIC230 lowered and with PDV384 closed. However, there was still excessive carryover to the PCD, and as a result, both FI680 and FI681 were reduced to lower the circulation rate.

The burner exit temperature was increased at 100°F/hr, and 3,000 pounds of sand was added to the reactor. The burner tripped for an unknown reason and was relit after decreasing both the solids circulation rate and the reactor pressure. The solid circulation rate was then raised by increasing FI680 and FI681.

The reactor pressure was increased to 75 psig. FI680 was reduced so that the level in the reactor standpipe could be built up using the solids in the HX0203. The reactor pressure was then increased to 80 psig to reduce the riser velocity. After establishing a sufficient level in the reactor standpipe, FI680 was increased to increase circulation. This resulted in a large carryover of solids to the PCD, and in an increase in the primary cyclone dipleg temperatures which indicated that the cyclone was experiencing a larger loading and a correspondingly larger separation of solids. FI680 was reduced to reduce the carryover to PCD and allow sufficient time to empty the PCD cone of solids. Once the PCD was empty of solids, both FI680 and FI681 were increased in preparation to perform a cyclone spoiling test. The spoiling gas was introduced into the primary cyclone to make sure that the solids in the cone section of the cyclone were draining freely into the radix. It appeared from the cyclone dipleg temperatures that the solids from the cyclone were flowing down as slugs. FI681 was increased to determine if we had solids carryover with reactor standpipe circulation alone. As more solids were added to reactor the differential pressure across the disengager increased, indicating an increased loading of the solids. The solids carryover to the PCD also showed a corresponding increase.

The spoiling gas tests were completed and all standpipe aeration nozzles were closed. No significant change in solids carryover or the flow of solids into the cyclone dipleg due to spoiling was observed. FI680 was increased to increase the circulation rate through the combustion heat exchanger and increase the level in the standpipe. PDV384 was opened, FI230 was increased, and FI680 was varied to expand the solid bed in the heat exchanger and increase the circulation through HX0203. Sand drained from the process was fed back into the reactor to increase the inventory levels, but the combination of solids circulation and solids feed to the reactor increased the solids carryover rate. The burner firing rate was decreased to lower velocities, but the solids carryover to PCD continued to be excessive so the reactor system was shut down on October 17. It was suspected that this excessive solids carryover resulted from a restriction in the cyclone system or possibly the solids not draining well from the Disengager and the Cyclone, resulting in reentrainment.

4.1.2 Test Run CCT2B

This test was the first test after the DOE project review meeting which was held on October 22 and 23. The period after the end of the last Test Run CCT2A (hot sand solids circulation test) was used to review the operating data obtained during the first coal combustion test (in August) and Test Run CCT2A (during which excessive solids carryover was experienced). Both MWK and GE Environmental Systems, Inc. (GEESI, Disengager and Primary Cyclone system vendor) were consulted about the excessive loss

of solids from the reactor loop during the hot sand circulation run. It was recommended that the solids level in the standpipe should be raised to seal the cyclone dipleg preventing gas from the disengager short circuiting the cyclone through the cyclone dipleg.

Review meetings were held between the Transport Reactor operating team, between the Transport Reactor and PCD operating teams, and observations and results were discussed with the operating staff. Also a process review meeting was held between SCS and MWK to understand the results from the previous coal combustion test and to try to find out why we had agglomerate formation during the test. Several useful resolutions came out of the review meetings. Some of the important ones are listed below:

1. Methods were identified to improve co-ordination between the transport reactor team and the PCD team.
2. The PCD team after reviewing the data from the previous test developed a better understanding of the PCD instrumentation and the interpretation of the temperature and differential pressure data. Previously, the filter differential pressure was monitored. The data analyses showed that monitoring the differential temperature profile in the PCD and FD0520 dump cycle would provide better indication of solids level and removal rate out of the PCD hopper.
3. Dolomite will not be used for bed material make-up, but only for sulfur capture. The requirement for sulfur capture is far less than the requirement for bed makeup.
4. An attempt will be made to add sufficient bed material to seal the cyclone dipleg.
5. To reduce the carbon build up in the bed during start-up, injection of carbonaceous material to assist reactor preheat will not be attempted until the mixing zone temperature is approximately 1100°F. Also, Belle Ayre sub-bituminous coal will be mixed with the coke breeze in a 3:1 ratio by weight to increase its volatile content and improve its ignition properties.

The deposits found after the hot solids circulation run in the disengager and cyclone were removed and the cross-over reconnected. These deposits were leftover from the August coal run. Figures 1 and 2 show the disengager before and after deposits were removed, and Figures 3 and 4 show the cyclone before and after the deposits were removed. Prior to this run, the reactor loop solids were drained to facilitate disengager cleaning but the combustor heat exchanger solids were not drained.

This was the first coal combustion test run planned after the successful August coal combustion test run. Preparation for the run began with pressure (leak) test of the reactor loop up to 300 psig on October 31, 1996. Minor leaks that were found at 300 psig were repaired after the reactor loop was depressurized to atmospheric pressure.

Figure 1. Disengager Cone covered with Deposits

Figure 2. Disengager Cone After Deposits Removal

Figure 3. Primary Cyclone Showing Deposit Behind Gas Outlet Tube

Figure 4. Cyclone With Deposit Removed

Preparation for the run continued on November 2 and 3. During this time, the Clyde solids conveying systems were tested and the discharge level probe in FD0220 was found defective. A minor leak through PV287 was discovered but was not fixed since PV287 is open during normal operation. The Transport Air Dryer, DY0210, and the Thermal Oxidizer were put in service. Because the Thermal Oxidizer had been shut down for more than 30 days, the manufacturer's recommended initial refractory heat-up schedule was followed.

The reactor loop was pressurized to 50 psig. With the steam drum pressure approximately 110 psig, the Primary Gas Cooler, HX0202, was placed in PCD pre-heat mode by closing the downcomer, opening the riser, and cracking open the blowdown valve. This way, steam from the steam drum was used to preheat the PCD to above the dew point before the start-up burner was lit. Shortly, all the process temperatures downstream of HX0202 showed a sharp increase. Although the main air compressor was not on at this time, nitrogen flow was established through the instrument nozzles. As soon as the HX0202 riser and downcomer were opened, the steam drum pressure dropped from 110 psig to approximately 100 psig. At this time, the gas inlet temperature to the steam coils in the thermal oxidizer was approximately 1000°F.

At approximately 09:00 on November 3, the first batch of sand (starting bed material) was transferred from FD0140 into the coal feeder, FD0220. Approximately 8000 pounds of sand was loaded into FD0220 for transfer into the reactor when needed.

At about 03:00 on November 4, 1996, PCD backpulsing was established, the main air compressor was started with its discharge pressure set at approximately 270 psig, and process flows to the reactor loop were set per operating instructions. The reactor loop pressure was increased from 50 psig to 60 psig and held constant at this pressure. The compressor discharge pressure was later increased to 340 psig to help clear the plugged process nozzles. Approximately 9,500 lb/hr of air was routed through the mixing zone injection nozzles to preheat the PCD to at least 200°F as measured by TI-439 before the BR0201 was lit.

In preparation for burner light off, the air flow through the mixing zone was reduced from ~9,500 lb/hr to ~4,500 lb/hr. Air flow was established through the quench flow nozzle to the burner. However, some operating difficulties were encountered when BR0201 combustion air was turned on. The flow would not increase when the valve was opened. After successful troubleshooting, the burner pilot was lit at 11:40. After the burner exit temperature quickly increased to 500°F, a three hour hold was begun per manufacturer's recommended heat up after a prolonged shut down. Quench air was used to control the burner exit temperature at 500°F.

At approximately 13:00, solids feeding into the reactor was initiated. Feeding was continued until all 8,000 pounds inventoried in FD0210 was transferred into the reactor. The transfer took approximately two hours giving an average transfer rate of 4,000

lbs/hr. Two additional batches of bed material were transferred into the reactor on November 4.

The initial increase in temperature in the Mixing zone, Riser, Standpipe and Riser exit (including Disengager and Cyclone exit) between 03:00 and 11:00 was due to the heat from the Main Air Compressor. The dip in temperature during this period was caused by the reduction in air flow in preparation for Start-up Burner light off. The sharp rise in temperature at 11:00 was due to the heat from the Start-up Burner. Since the Reactor J-leg was not sealed, some of the hot gases from the burner by-passed the Riser up through the Standpipe. Before solids addition was started, the reactor J-leg aeration flows were biased towards the top in an attempt to prevent the hot gases from the Burner from entraining the solids collecting in the lower portion of the standpipe thus preventing solids accumulation there. As soon as the solids injection started, the cold solids entering the reactor cooled the hot gases from the burner and caused the reactor temperature to suddenly drop. Thereafter, the reactor temperature profile increased at a slower rate. During filling of the reactor standpipe, fluidization/aeration in the HX0203 loop was minimal.

During the J-leg filling, solids migrate from the bottom of the Mixing zone into the Burner duct (J-leg). The presence of solids was indicated on PDI-370. As the solids fill the burner J-leg, they create pressure fluctuations that affect the flame stability in the Burner. In order to improve the pilot flame's stability, both the quench and combustion air flowrates were increased.

As the solids level in the Standpipe increased as a result of bed material addition, the solids circulation through the reactor also increased. This in turn increased the solids loading to the cyclone system. By the time the first 8,000-pound batch of bed material was transferred into the reactor, the loading to the PCD increased as a result of increased solids loading to the disengager/cyclone system. At around 14:45, bed material feeding into the reactor was temporarily stopped to allow the material captured by the PCD to be drained out through the Fines Screw Cooler, FD0502, which was running at 12 rpm (~15% above design). The draining of the PCD cone was trended using the pressurization and depressurization of FD0520 lock vessel below the Fines Screw Cooler. Each dump cycle (if the lock vessel is filled to the probe) corresponds roughly to 120 lbs of material. Between 14:30 and 15:00 when solids feeding was stopped, FD0520 cycled approximately six times corresponding roughly to 840 lbs of solids lost at a rate of 1,680 lbs/hr. As the solids loss continued from the reactor system, the solids level in the Standpipe dropped. The Riser superficial velocity which was reduced to bring the velocity to design and to observe how the solids separation system performed.

Solids samples were taken from the discharge of the PCD and analyzed for their particle size distribution. The geometric mean size was not significantly different from the feed sand. A similar trend was observed in the previous test run in October 1996.

After the PCD cone was cleared of solids (at 15:00), the second batch of bed material inventoried in FD0210 was fed into the reactor. Again, as noted previously, as soon as the bed level in the Standpipe began to increase, the solids loss rate from the reactor into the PCD also began to increase as indicated by the closeness of the pressurization/depressurization pulses. The second batch of bed material transfer was completed at about 19:00. Between the start and finish, the lock vessel cycled approximately 20 times giving a loss rate of approximately 350 lbs/hr (as measured by FD0530 weigh cells). At 17:45, the Riser superficial velocity was increased from 25 ft/s back to ~33 ft/s in an attempt to increase the Cyclone inlet velocity. Around this time, sand feeding into the reactor was stopped. However, because the Standpipe solids level was high, solids circulation through the Reactor loop was also high resulting in continuous loss of solids from the Reactor into the PCD as the Cyclone system was not operating efficiently. The Standpipe solids level continued to drop at a steady rate and leveled out at around 18:00. Once this happened, solids carryover to PCD also was reduced. Between 18:00 and 20:30 when the next batch of coarse sand was added, FD0520 cycled only about four times giving a loss rate of approximately 220 lbs/hr. At 19:00, FD0210 was de-inventoried of fines sand, and a coarse batch of sand was loaded.

At approximately 20:30 on November 4, the coarse sand batch inventoried in FD0210 began being transferred into the Reactor. This resulted in an increase in the Standpipe solids level. As soon as the Standpipe level began to increase from its steady value, solids carryover to the PCD also increased. Solids transfer was stopped at around 22:15. Between 20:30 and 23:30, FD0520 cycled 15 times giving a loss rate of about 450 lbs/hr (as measured by FD0530 weigh cells). The solids loss appeared to be tapering off as the Standpipe level returned to its previous steady state level. The solids sample from the FD0520 dump had a geometric mean of 178 microns.

While solids were being fed into the Reactor, the Burner firing rate was held constant on pilot only. Also, HX0203 was fluidized but was not circulated. Fluidization to HX0203 j-leg was maintained at minimum. From the pressure differential profile, it appeared that some of the material added to the Standpipe got transferred into the HX0203. To prevent moisture condensation in the spent solids discharge system, the FD0206 was run for a brief period every 2 hours. The spent solids transporter, FD0510, was also cycled.

At approximately 01:20 the next day (November 5), an attempt was made to start solids circulation through the HX0203 loop. The HX0203 dilute phase pressure control valve, PDV384, was opened 100% from fully closed position. In an attempt to initiate solids circulation, air flow through FI680 (HX0203 J-leg fluidization) was increased. However, most of the J-leg nozzles were found plugged with solids. Several attempts were made to blow clear the nozzles at 60 psig. The reactor was depressurized to 40 psig, and some of the nozzles were cleared. The HX0203 was made operational at around 10:00; however, one of the boot fluidization taps was plugged.

Operating conditions were maintained essentially "steady" until at around 14:30 when the main burner gun was lit. After the main burner gun was lit, the burner was maintained at a firing rate constant for the rest of the day. The reactor loop temperature profiles for the Mixing zone, Riser, Standpipe, Cyclone dipleg and Reactor exit showed increases in temperatures as a result of main burner firing. Temperatures downstream of the Cyclone also increased when the main burner was lit. Prior to this, the solids circulation rate steadily decreased as the material lost to the PCD was not recycled back into the reactor. Neither was fresh material fed into the reactor. The average solids loss rate between 00:00 and 14:00 was approximately 150 lb/hr. FD0520 lockvessel had only 15 dumps during this period. The size distributions of solids samples taken from the PCD drain on November 5 were compared with other samples. In addition to samples from FD0520, composite material transferred from FD0530 into the ash silo was sampled and their size distributions were determined. These samples were used to determine if the samples from FD0520 outlet were representative of the solids captured by the PCD since these samples were taken insitu while the material was being transferred from FD0520 into FD0530. The differences between ash silo sample and FD0520 sample can arise due to the timing (with respect to backpulsing) of the FD0520 sample and the frequency of FD0520 dumps.

The Reactor loop pressure was increased from 60 to 80 psig at approximately 15:00 and then to 100 psig at around 17:00. Each time before the reactor pressure was increased, the propane supply and the burner pilot differential pressures were increased. This was done to increase the propane flowrate through the pilot and move the flame front away from the pilot tip and prevent the tip from burning up.

To counteract the continuous drop of solids level while additional make up solids was not being injected into the bed and also to reduce thermal stress between the Reactor loop and the HX0203 loop, the HX0203 solids were circulated after 15:00 on November 5. This additional circulation from the HX0203 caused the Riser and Mixing zone densities to increase and the additional material transferred from HX0203 into the Standpipe increased the solids level in the Standpipe. After a brief period solids circulation from HX0203 dropped because the HX0203 standpipe was not adequately fluidized due to loss of aeration (nozzles plugged). All HX0203 related aeration nozzles were made operational by 18:00 and solids circulation rate through HX0203 was established. By 22:00, the solids loss rate to the PCD was increasing rapidly, and to counteract this, the solids circulation through HX0203 was reduced through manipulation of the aeration/fluidization flows. The increase in solids circulation through HX0203 is manifested by a sharp increase in HX0203 solids/vapor phase temperatures as hot solids from the standpipe entered the heat exchanger.

After the process temperatures inside HX0203 approached 300°F, the burner firing was increased at 00:28 on November 6. At that time, the skin temperatures were such that the differential temperature between the HX0203 and the Reactor loop was within limits. Skin temperature profile taken at 01:00 showed a difference of 50°F between HX0203

loop and the Reactor loop (compared to a maximum of 135°F allowed). The results of another skin temperature survey taken at 07:30 showed differential skin temperatures between the Riser-Mixing zone and Standpipe of 11°F; between Primary cyclone loop and Standpipe of 3°F; between the Standpipe and HX0203 loop of 19°F; and between HX0203 loop and Riser-Mixing zone of 30°F. Results of the skin temperature surveys are summarized in Table 1.

Table 1. Results From Reactor Loop Skin Temperature Surveys

Date	11/6/96	11/6/96	11/7/96
Start Time	06:30	14:00	07:35
End Time	07:30	15:08	08:35
Riser Exit Temp., °F	750	925	1100
Avg. Riser/Mixing Zone Skin Temp., °F	134	169	179
Avg. Standpipe Skin Temp., °F	123	148	166
Avg. Cyclone Skin Temp., °F	127	149	160
Avg. HX0203 Loop Skin Temp., °F	104	117	115
Differential	Temperatures	°F	
Riser/Mixing Zone & Standpipe	11	21	13
Standpipe & Cyclone	-3	-1	6
Standpipe & HX0203 loop	19	31	52
Riser/Mixing Zone & HX0203 loop	30	52	64

Reactor heat up was continued by increasing the burner firing rate. Flows were adjusted to maintain a reasonable solids circulation through the reactor without excessive solids carryover. The reactor pressure was kept constant at 100 psig. Around 13:00, the application workstation crashed leading to the temporary loss of the data acquisition system (PI system). It was brought back on-line around 23:00. While the PI system was being serviced, the reactor heatup continued. At about 23:30, the Mixing zone temperatures were above 1000°F and preparation for coke breeze/coal assisted preheat began.

At about 00:00 on November 7, the Sorbent feeder, FD0220, was inventoried with coke breeze and sub-bituminous coal mixture (3/1 weight ratio). The coal feeder was planned to be used for bed make up. Also, because the feedrate of FD0220 (50 lb/hr minimum) is much lower than that of FD0210 (400 lb/hr minimum), feeding from the sorbent feeder would permit a better control over the feedrate during start-up.

At approximately 05:00 coke breeze/coal mixture was fed batchwise into the Reactor. After the first batch of coke breeze/coal mixture was injected into the Reactor, a second batch of approximately 1,100 lbs of coke breeze/coal mixture was loaded into FD0210. At 07:30, continuous feeding into the reactor was started. HX0203 up to this time was circulated periodically for a short time to heat up the HX0203 loop to increase its loop skin temperature. As coke breeze/coal mixture feed injection continued, the reactor loop temperature began to increase. To control the temperature rise, continuous solids circulation through HX0203 was started. However, as soon as the solids circulation through the HX0203 started, the solids carryover rate to the PCD sharply increased. Between 07:45 (when continuous HX0203 circulation started) and 12:20, approximately 3,800 lbs of material was lost from the Reactor loop at an average rate of 830 lb/hr, mostly from HX0203. After stable combustion was achieved, the Startup Burner was shut down at approximately 10:00.

To control the Reactor temperature without increasing the solids loss, the HX0203 solids circulation was reduced and air flow was established through the Riser staged air nozzles to provide some cooling and help maintain Reactor temperature between 1450 and 1600°F. Also, the Reactor feeding was switched from continuous to batch mode. When the Reactor temperature reached a maximum of 1600°F, the coke breeze/coal mixture feeding was stopped and when the temperature dropped to 1400°F, feeding was resumed.

At 14:30, after noticing that the fines screw cooler had tripped and being unable to discharge solids from the PCD hopper, the coke breeze/coal feeding was stopped. The solids circulation through the reactor was reduced to allow the PCD cone to be cleared of solids after FD0502 was restarted. At 15:00, the PCD appeared to be empty of solids. The reactor pressure was reduced from 100 psig to 70 psig because the Startup Burner would not light at 100 psig. The Startup Burner was lit at 70 psig for reactor re-heat. After approximately 2 hours, the start-up burner tripped. After several unsuccessful attempts to light the burner, including reducing reactor loop pressure, the test was terminated since the reactor temperatures were too low for coke breeze/coal mixture to ignite.

4.1.3 Test Run CCT2C

The Combustion Characterization Test run, CCT2C, was carried out between November 14 and November 22, 1996. On November 13, the MWK Transport Reactor Train startup was initiated. The Thermal Oxidizer was lit and fired to reach 150 psig steam drum pressure. The HTF system was started and the Nitrogen system was lined up. The

Primary Gas Coolers were lined up to preheat the PCD. The Main Air Compressor was started and the reactor was successfully leak tested at 50, 160 and 300 psig. The Clyde systems were started to check their operations. In preparation for adding sand into the reactor 2.5 drums of sand were loaded into FD0140.

On November 14th the PCDs continued to be preheated. The reactor pressure was reduced to 60 psig and backpulsing of the PCD was initiated. The spent solids screw cooler was run periodically to ensure that it was not plugged. The differential pressure indications were rebalanced and the corresponding instrument purges were set, and the steam was lined up to the propane vaporizer. Around 08:30, the PCD temperature (TI439) reached 200 °F. At 10:00, the Startup Burner pilot was lit but tripped several times during the next thirty minutes. It appeared that the 1250 scfh cooling purge flow to the flame tip was high. It was determined that the flame tip cooling purge flow above 950 scfh trips the burner. Around noon, sand addition (~1400 lbs) to the reactor was started at 1% motor capacity (3.7 rpm). This sand came from draining about 2 drums from HX0203 on 11/11/96. As the aeration on the cyclone dipleg was turned on, cyclone dipleg temperatures (TI382, TI441 and TI442) started increasing. To confirm this, the aeration was turned off at 13:50 and the temperatures started decreasing. As the sand was added, the upper standpipe temperature (TI357) started increasing which shows hot sand, as it was being added, was coming down the Disengager. At about 13:50, TI357 started decreasing which indicates the completion of sand addition through FD0210.

Around 14:05, coarser sand (Type T30/T50 from Badger Mining of Berlin, WI) was added to the Reactor. The coal feeder tripped several times. Minimum aeration flows were being set as sand was being added to the Reactor. All HX0203 J-leg aeration nozzles were plugged and had to be blown out. By 15:30, 3000 lbs of sand was loaded into the Reactor. Another 3000 lbs of sand was transferred from FD0140 into FD0210.

At about 15:00, PCD cone temperatures increased due to solids carryover (due to fluidization in the standpipe when standpipe nozzle block valves were being opened). Even though TI501 and TI505 and the FD0520 dumps showed no further carryover for the next three hours, the PCD cone temperatures stayed around 200°F. TI505 appeared to have come down to where it was before carryover. TI501 had a new baseline temperature which was about 60 °F higher than before carryover.

Initial attempts to light the burner around 17:00 were unsuccessful due to a high pressure drop in the Burner J-leg (>60 in H₂O). Air flow through the Burner J-leg via FIC365 and 366 was increased and the Reactor pressure was decreased to lower the pressure drop. The main burner was then successfully lit at a Burner J-leg differential pressure of about 35 in. The reactor pressure was then increased to 60 psig. About 40 minutes later the startup burner tripped probably due to a fluctuation in the propane flow at the vaporizer. The Burner was successfully relit. Solids circulation in the Reactor was established by adjusting the Reactor j-leg aeration. The solid bed in the HX0203 was fluidized and the aeration in the HX0203 J-leg was slowly increased to initiate circulation through the heat

exchanger. Throughout this test run, the solids circulation through the heat exchanger was poor due to bridging at the intersection of HX0203 standpipe and J-leg. The aeration flows in the HX0203 standpipe and J-leg and bed fluidizing air flowrate were often adjusted to unbridge and induce circulation.

At 02:45 on November 15, running FD0220 was attempted but it plugged in 5 minutes. The block valve to the reactor was closed, and the dispense vessel was depressurized. The reducing elbow from the feeder was rodded out through the bottom block valve. The dispense vessel was then repressurized and air flowed through satisfactorily. The FD0220 feeder was started again at very low speed, 1 rpm. There continued to be some plugging problems in FD0220. At 06:33 the HX0203 boot and standpipe flows were reset to improve circulation through HX0203. Around 07:00 the Startup Burner firing was lowered to reduce temperature (~800 °F) at the Primary gas cooler (HX0202) inlet so that the downcomer could be cut in, and starting at 07:30, the downcomer was gradually cut in. By 10:00, the HX0202 downcomer was fully opened with blowdown fully closed, placing the primary gas cooler in steam production mode.

The BR0201 firing rate was increased to increase the Burner exit temperature to 1475°F. At 10:15, solids addition from FD0210 was started. The initial weight was 3300 lbs. FD0210 tripped 2 times during the loading so the feeder speed was increased. As solids were added, the standpipe level increased. At 11:55, the ball valve to collect a batch sample of particles was opened by Southern Research Institute (SRI). At 12:15, the 1 hour warming up of SRI's sampling system was started. Fifteen minutes later the FD0520 was forced to cycle to take a sample in order to compare with the SRI batch probe sample. From 13:20 to 13:40 SRI took the sample with their batch sampling probe.

At 13:45, propane pressure at the trench was increased to 200 psig and subsequently the Reactor pressure was increased from 65 to 80 psig with a corresponding increase in the pilot propane pressure. At 17:00, the Reactor pressure was increased to 100 psig and the Startup burner pilot differential was set to 70 psi. In order to better evaluate the flow of gases around the Disengager, Primary cyclone and its dipleg, PDT250 and PDT254 were taken out of service to repipe the transmitters. After establishing solids circulation through HX0203 by adjusting aeration flows and unbridging the solids near the bottom of the heat exchanger standpipe, the HX0203 J-leg aeration was reduced at 19:40 so that the circulation rate through the combustion heat exchanger would decrease and the reactor loop temperature could rise faster. Six drums of the coke breeze and PRB coal mixture (3 to 1 weight ratio) were added to FD0140 bin for transfer to FD0220. The total amount of coal and coke breeze mixture transferred to FD0220 was 1750 lbs.

At 20:40, FD0220 was started and the feeder speed was gradually increased to 6% over the next hour. At 23:20, the Startup burner tripped, and it was relit. By 23:21 the Pilot and main burner were lit. At 23:38, the Startup burner and the Reactor system tripped. The cause seemed to be the Main air compressor which unloaded and tripped everything in the Reactor loop. The alarms were reset and the Compressor was loaded.

The pilot and main burner were relit around 00:00 on November 16. The Main air compressor continued to have control problems so it was placed in manual. After establishing all the aeration flows and solids circulation, coal and coke breeze mixture feed to Reactor was started at 01:17 using FD0220 at 1.11 rpm (3%). From 01:38 to 02:44, the FD0220 feeder speed was increased from 4 to 8% (1.68 rpm) in steps of 1%. The FD0220 feeder speed was further increased gradually to 15% (2.45 rpm). Coke/coal mixture feed continued through FD0220 at the same rate to bring up Reactor temperature. At 07:15, the Startup burner temperature was at 1950 °F. The differential pressure across CY0201 was slightly higher than across CY0207. Total gas flowrate in and out of the Reactor was about 16,200 lbs/hr. The Mixing zone temperatures varied from 1120 to 1220 °F, the Riser temperatures were around 1220 °F, the Standpipe temperatures varied from 1070 to 1170 °F, and the Cyclone dipleg temperatures were between 900 and 1000 °F. The PCD gas inlet and outlet temperatures were between 500 and 550 °F.

At 07:20, about 1,000 lbs of sand in FD0210 was fed into the reactor to build level in Reactor standpipe. At 09:15, the average coke/coal feedrate was 126 lb/hr. The Riser temperatures were close to 1300 °F. FD0220 feeder speed was increased from 2.45 to 3 rpm. Solids from HX0203 were periodically circulated to make up for the level in the Reactor standpipe. At 10:00, HX0203 circulation was initiated for a short period by increasing the boot, standpipe and J-leg aeration. Circulating cold solids from HX0203 caused the reactor temperatures to drop by ~ 100°F. The feedrate from FD0220 was further increased gradually to 3.49 rpm giving a coke/coal mixture feedrate of about 160 lbs/hr.

At about 14:00, the FD0220 feeder speed was increased to 5.51 rpm. Even though the Mixing zone temperatures were around 1250 °F and the top of the Riser temperatures were around 1370 °F, the temperature rise was slow since most of the coal/coke breeze mixture that was fed was getting carried to the PCD. Also, the circulation through the Reactor J-leg slowed down due to the Standpipe level decrease. Solids from HX0203 were used to increase the level in Standpipe typically from 110 to 160 inWG on PDT259.

The Riser temperature continued to increase gradually. At 16:30, when the Riser temperature was about 1450 °F, the FD0220 feed was reduced from 5.51 to 5.25 rpm due to excessive carryover to the PCD (~8 FD0520 dumps/hr). The Riser temperature decreased by about 15 °F and PDT259 steadied around 135 inWG. Due to incomplete combustion, it appears that only part of the feed was getting back into the Standpipe and the rest was carried over to the PCD. The FD0502 speed was increased from its nominal operating maximum of 8.2 rpm to 12.17 rpm. The speed indication on the PI system were smoother at 12.17 rpm and the higher speed provides increased fines removal capacity.

At 18:00, the Burner exit temperature was 1994°F and since the Reactor temperatures could be maintained through coal/coke breeze mixture combustion, the Start-up burner

firing rate was reduced. The FD0220, set at 5.3 rpm, was feeding about 167 lbs/hr based on the FD0220 weigh cells.

At 19:10 the FD0220 feedrate was increased to 40%, and the Riser temperature was around 1550°F. At 20:00, after-burning in the Cyclone dipleg was indicated by TE441 climbing to 1650 °F. The coal feedrate and the solid circulation rates were reduced. Also, at 21:00, the flow rate on one of the aeration nozzles in the dipleg (FI811) was fully opened to reduce after-burning in cyclone bottom and dipleg.

At 21:15, the start-up burner firing was increased in an attempt to confine the coal/coke breeze combustion in the Reactor instead of Cyclone dipleg. Also, the FD0220 speed was reduced to 37%. At 22:00, the compressor surged, tripped and shut down the burner. The Start-up burner pilot and main burner were relit. The Riser temperatures dropped from about 1500 °F to 1000 °F.

On November 17, at 00:36, when the Mixing zone temperatures reached about 1200 °F, coal feeding resumed with the feeder speed set at 5%. The FD0220 speed was gradually increased to about 38%. After-burning again occurred in the Cyclone dipleg. At 03:00, 3 drums (960 lbs) of Calumet mine bituminous coal were transferred from FD0140 to FD0220. FD0520 was forced to cycle to test whether the spheri valve is functional since FD0520 didn't dump for a long period of time. The FD0520 functioned normally.

At 07:14 the Startup Burner tripped. The propane vaporizer was suspected of causing a fluctuation in the propane flow. At 07:30 the burner was relit after reducing the J-legs aeration rates in order to increase the Burner quench flow and blow the solids from the Burner J-leg. This reduced the differential pressure across the Burner J-leg. Since the solids circulation through the HX0203 continued to be a problem, the heat exchanger fluidization velocity was increased to expand the exchanger's bed of solids to determine if this will give better control of circulation of solids through the heat exchanger. The bed expanded and with an increase in HX0203 J-leg aeration, the solids circulation through HX0203 J-leg was established. The Reactor standpipe level as measured by PDT259 also increased to 160 inWG. Two drums of T30/50 sand was transferred from FD0140 into FD0210 for make-up.

At 11:10, with the Mixing zone temperatures above 1200 °F, the coal feed speed was started from FD0220 at 1RPM and increased to 6 rpm over the next 2.5 hours. At 13:45, the Standpipe level was again increased from 130 to 155 inWG (PDT259) by establishing circulation through the HX0203 J-leg for a short period of time. At 14:50, the coal feed speed was further increased to 7.5 rpm.

Based on solids loss calculations from the Reactor (solids addition, Standpipe level changes and heat exchanger level changes), the solids loss rate over the previous 24 hours (excluding trips) was about 250-300 lbs/hr. The number of dumps to the PCD while feeding coal was about 8-10 per hour. It appears that the density of PCD carbonaceous

ash was about 30 lbs/cuft. The FD0530 weigh cells show that each FD0520 dump was about 15 - 25 lbs. It was hypothesized that the FD0520 lockhopper vessel may have had solids sticking to the wall of the vessel which may have reduced the amount removed through FD0520. Also, solids from FD0520 dispense vessel appeared to move to the FD0530 surge bin much faster either due to the material being lighter or less amount of material per dump. (It was subsequently found that the fines from the PCD were sticking to the sides of the FD0520 lockhopper and thereby transferring a much smaller amount per dump.)

At 15:10, coal feeder speed was increased to 8 rpm. The burner firing was decreased since the Riser velocities were high. The propane flowrate was maintained at about 195 lbs/hr and the burner exit temperature around 1925°F. The FD0220 feeder speed was increased from 8 rpm (63%) in steps of 0.2 rpm to maintain the Riser exit temperature between 1575 and 1600 °F. At 15:55, 5 barrels (1600 lbs) of bituminous coal were transferred into FD0220.

At 16:05, FV364 was set to 65% with FI364 around 163 lb/hr. While waiting on the reactor to equilibrate, the Riser temperatures started to increase rapidly. The burner firing was decreased even further to an exit temperature of 1670°F. The temperature was still increasing so the coal feed was gradually reduced from 67% to 64% (8.1 rpm). PDT259 was steady at 145 inWG. At 17:55, five drums of coal were transferred to FD0220 from FD0140.

Around 18:00, since the coal feeder (FD0220) tripped a couple of times, the burner firing rate was increased. At 18:20, sand addition to the reactor was started from FD0210, but the FD0210 feeder kept tripping. At 18:30, FD0520 was investigated and gas was found to be continuously leaking through the vent valve XV8539 (a ball valve). This could have been the source of premature level indication in FD0520 and also the cause for the 5-10" differential pressure on the FD0530 vent filters. By 18:40, all sand had been fed from FD0210 to the reactor so that FD0210 could be used as a backup to FD0220.

At 19:40, 1143 lbs of coal was transferred to FD0210 due to the problems with FD0220. At 20:00, startup burner firing was decreased. At 21:15, the Startup burner tripped probably due to a fluctuation in propane flow. As the temperatures in the Reactor could be maintained with coal combustion, the burner was not relighted. The HX0203 boot and standpipe aeration was pulsed and adjusted to initiate solids circulation. The reactor pressure was gradually increased in small steps from 100 psig at 21:30 to 180 psig at 09:00 on November 18 and then reduced back to 160 psig. The process was operated at 160 psig for the remainder of this test run. The instrument purge flows were set to 160 psig operation.

The FD0220 feeder speed was set to 100%. The corresponding coal feed rate was about 400 lbs/hr. As FD0220 surge bin was being emptied, about 3000 lbs of coal was transferred from FD0104 into FD0210, and at about 23:00, coal feed resumed from

FD0210. The estimated coal feed rate was about 520 lbs/hr. As Reactor temperatures continued to increase, coal was fed in batch mode from FD0210.

At 01:05 on November 18, about 3120 lbs of sand was loaded to FD0220. The sand was fed from FD0220 until about 07:30, and during this time period, the Standpipe differential pressure (PDT259) increased from 130 to 190 inWG. As the Standpipe level increased, the circulation rate and carryover to PCD also increased. The coal feed rate during this time period ranged from 490 to 720 lbs/hr.

At 08:50, sand feed resumed from FD0220 and continued until 14:00. The HX0203 J-leg aeration rate was reduced to decrease the solids carryover to PCD while problems associated with the Transport air dryer were being investigated. At 11:20, the Main air compressor was put back in automatic. At 14:15, PDT250 and PDT254 were repiped and reconnected so that PDT250 read pressure loss across CY207 hopper, and PDT254 measured the differential between the standpipe and cyclone dipleg. At 14:30, the Reactor standpipe aerations were pulsed and set to specified values.

After all the sand in the bin was fed, coal was added to FD0220. Coal was fed from FD0220 whenever problems developed with FD0210 or when the feedrate from FD0210 was high and could not be adjusted to control the Reactor temperature. Between 18:00 and 23:00, the coal feedrate varied from about 650 to 730 lbs/hr. As the Standpipe level was low at about 120 inWG as measured by PDT259, about 3000 lbs of sand was added through FD0220 between 01:00 and 05:00 on November 19. Continuous coal feed was maintained with FD0210, and during this time period, the coal feedrates ranged from 590 to 720 lbs/hr.

The coal feed was switched from FD0210 to FD0220 a few times due to FD0210 tripping (because of lock vessel top spheri valve failure to close alarm). Also, coal was batch fed from FD0210 as the reactor temperature was high with minimum speed on the feeder. At 12:20, the coal feeder speed was changed for better turndown. Coal was fed continuously from FD0210 as a result of lower minimum speed. About 3000 lbs of sand was added using FD0220 between 11:30 and 15:00. However, most of it seemed to escape into the PCD because there was little accumulation in the Standpipe and HX0203.

Up to 14:20, about 29,000 lbs (14.5 tons) of coal had been fed into the reactor. The coal feedrate was about 575 lbs/hr which was close to the value calculated based on CO₂. Intermittent sand addition to the reactor from FD0220 was resumed at about 17:30. The skin temperature differentials calculated using the midnight readings were as follows: 22 °F between Riser/Mixing zone and Standpipe, 5 °F between Standpipe and Cyclone dipleg, 90 °F between Standpipe and HX0203, and 112 °F between Riser/Mixing zone and HX0203.

The Mixing zone, Riser and Standpipe temperatures were quite stable after 12:00 on November 19. Stable reactor temperatures and Standpipe solids level continued into

November 20. No sand was fed between 03:00 and 14:00. At 11:00 the Reactor temperatures started decreasing and the excess oxygen started increasing because the coal feeder speed dropped due to unknown reason. The feeder speed was increased (from 1 to 1.5% of motor capacity) which resulted in higher stable Reactor temperatures (from 1534 to 1584 °F highest temperature in the Riser) with decreased excess oxygen level in the gas.

The coal feedrate was about 578 lbs/hr. All staging air nozzles were fully open. Approximately 2080 lbs/hr air flow was flowing through the three staged air nozzles. At 11:40, the riser cross-over was blown for 5 minutes by increasing the third stage air flow. It did not appear that a significant amount of "salted" material (if any) was being blown from the Cross-over into the Standpipe. The flows were reset to the prior values after the test.

Between 14:20 and 17:00, 1380 lbs of sand (T30/T50 type) was added to the Reactor. At 15:50 Cyclone spoiling tests were started by setting FIC444. FIC444 was increased from 0 to 1500 lb/hr (and decreased again) in increments of 500 lb/hr to see its effect on Cyclone performance. No noticeable change in Cyclone performance was observed. As the Reactor operations were stable, the coal feedrate was slowly increased from about 1% to 2.1% (3.1 to 3.6 rpm) of feeder motor capacity by 22:30.

The Reactor inventory levels were self-sustaining with the ash generated in the process at the higher coal feed rate. At 06:00 on November 21, the coal feed rate was reduced from 2.1% to 1.3% to reduce the maximum reactor temperature from 1670 °F to 1600 °F. At 07:55, as sand was not being used, 1540 pounds of sand was drummed out of FD0220 and 500 pounds of dolomite was transferred into FD0220. At 08:23, FD0220 was started, but dolomite addition into the reactor did not actually occur until 08:40 because of the sand that was left in dispense vessel. Dolomite addition was indicated when the SO₂ level in the gas stream dropped from about 110 ppmv to 46 ppmv. The coal feedrate was about 600 lbs/hr. Estimated dolomite feedrate was 600 lbs/hr. By 09:00, the SO₂ concentration had dropped to 25 ppm. The FD0220 feeder speed was reduced from 2.5 rpm to 1.2 rpm, and another 500 lb of dolomite was transferred into FD0220. Total coal fed by 08:45 on November 21 was about 22 tons.

At 09:50, SRI started sampling the inlet to the PCD. At 10:00 the sorbent feed rate was estimated at 200 lb/hr with feeder at 1.2 RPM. By 10:25, SRI had finished collecting the sample. The desulfurization rate was estimated as 93% at a SO₂ concentration of 16 ppmv. The dolomite feed was stopped to determine the system response by monitoring SO₂ emission. By 11:10, SO₂ concentration increased from 16 to 25 ppm, and by 11:25 SO₂ concentration increased to 47 ppm. Dolomite feeding at that time was then resumed at 0.7 RPM.

At 11:28, the FD0220 speed was set to 0.9 RPM equivalent to a Ca/S = 3/1. From Cyclone dipleg temperatures, it appeared that the Cyclone operations were smoother with

dolomite addition to the reactor. At 12:20, FD0220 speed was increased to 1.2 RPM to increase dolomite feedrate back to 200 lb/hr, so that FD0220 could be emptied to feed sand into the reactor to bring up solids level in the reactor.

Starting at 13:30, about 300 lbs of sand were fed into the Reactor, and the Standpipe level increased from about 99 to 117 inWG. An additional 1600 lbs of sand was added into the Reactor. At 18:25, 650 lb of dolomite was added into FD0220. To test the maximum coal combustion rate, the coal feeder rate was increased from 1.8% to 3.0 % over the next 3.5 hour. At 19:35 dolomite feed was started at 10% motor output (1.9 rpm) of FD0220. The SO₂ composition, according to the analyzer, dropped from about 130 ppm to 20 ppm. At 20:45, FD0220 speed was reduced to 1.7 rpm., and 566 pounds of dolomite was transferred into FD0220.

At 21:48 FD0210 tripped due to a lock vessel spheri valve failure. The feeder was restarted. Again, around 23:57, FD0210 tripped 3 times - as a result of lock vessel spherical valve failure to close or due to the vessel failing to pressurize. Very little coal was flowing through the FD0210 storage bin to the lock vessel. The gate valve at the bottom of the bin was fully opened to no avail. Five drums of coal were drummed out of FD0210 to transfer coal to FD0220. The coal feed rate was reduced to 2.1% motor output, because the feeder was having problems. The FD0210 tripped at 00:52 on November 22, because the lock vessel failed to pressurize. From 01:10 to 01:28, FD0210 tripped three times because the lock vessel spheri valve failed to close the alarm. At 01:36, FD0210 was shutdown due to operational problems, and FD0220 was started. The FD0220 was used to maintain the reactor temperature while FD0210 operating issues were studied. There were also problems with fluctuations in the Main air compressor flow, and as a result, the air compressor was put in manual control.

By 06:15 on November 22, the coal feeder seemed to be working. At 06:20 a coal sample was taken from FD0210 surge bin to find out if the coal was wet. The FD0220 gear speed was adjusted to give 15-20% more speed above design in order to achieve a higher coal feedrate using FD0220. At 07:00 FD0210 tripped and was re-started. At 07:05 FD0220 was started. At 09:13, the isolation valve on FD0210 surge bin was closed halfway and fluidization was checked. The fluidization rates were set at normal rates.

By 10:45, the FD0210 feeder was working better. At 11:30, coal was drummed out of FD0220 to add 2 drums of sand as the Reactor standpipe level was low. At 12:00, there were hot spots in the Reactor, and as a result, coal was batch fed to keep the maximum temperatures low. The TI357 temperature (top of Standpipe) stopped increasing and the Standpipe temperatures steadily decreased and were low (about 300 - 400 °F instead of 1500 - 1600 °F). Even with addition of sand and circulation of solids from HX0203, the Standpipe level did not increase. Further increase in solids circulation from HX0203 resulted in higher carryover to PCD. It appeared that the J-leg seal was lost due to low solids level in the Standpipe and the reverse flow of gases through the Standpipe

prevented solids from flowing down the Disengager and Cyclone dipleg. At that point, operations proceeded to shutdown the process.

At 14:00, the coal feeder was shutdown. At 14:20, the reactor pressure was reduced from 160 to 100 psig. All Standpipe and Reactor solids were removed by using FD0206. The Standpipe solids were drained into FD0530 as Reactor system shut down proceeded. The PCD was backpulsed for 2 additional hours. At 18:25, the main air compressor was shut down.

In summary, this characterization test run was started on 11/14 with Startup burner lit at 10:00. Until the Transport reactor train was taken off-line on 11/22 at 14:00, the following operational hours were realized: The Startup burner was on between 11/14 at 10:00 and 11/17 at 21:17 for 82 hours (83 min was lost due to trips); the cokebreeze and PRB coal mixture was batch fed between 11/15 20:30 and 11/16 07:20 for 9 hours and 20 minutes (100 minutes was lost due to trips); and the Alabama Bituminous coal was fed for 146 hours between 11/16 07:20 and 11/22 14:00 (4 hours and 40 minutes was lost due to trips).

4.1.4 Test Run CCT3A

On December 11 and 12, 1996, testing was performed at different circulation rates and riser velocities to study the efficiency of the disengager. The efficiency of the disengager was about 85% during these tests. This run was made to support resolution of the problem with excessive solids carryover from the cyclone to the PCD. More details will be forthcoming in the next progress report and future commissioning report.

4.2 PRELIMINARY DATA/EVALUATION

During the fourth quarter there were four test runs with the MWK Transport Reactor. In the third test run, CCT2C, between November 14 and November 27, 1996, the reactor operated on coal for 146 hours. Process raw data for this run are given in Figures 5 to 18. The Figures give trends for various tags in two time periods: November 14 through November 17 and from November 18 to November 22. Figures 19 and 20 show the BR0201 and reactor temperatures for test run CCT2B.

4.2.1 Coal/Solids Rates

For 11/16/96 and 11/17/96, the coal feed was from FD0220. For 11/18/96 through 11/22/96, the majority of the coal came through FD0210, but with some switching back and forth between the two feeders. For 11/18/96-11/21/96 the coal rate was about 600 lbs/hr by the weigh cells. During 11/19/96, the coal rate via the weigh cells became erratic and very hard to read. The coal feed rate for 11/16 through 11/22 is tabulated in Table 2 and expressed graphically in Figures 21 and 22 (lb/hr and feeder speed, respectively). Sand addition is shown in Table 3.

Figure 5. Startup Burner Propane Flow and Outlet Temperature

Figure 6. Reactor Mixing Zone Temperatures

Figure 7. Standpipe Differential Pressure/Reactor Pressure

Figure 8. Standpipe/Dipleg Temperatures

Figure 9. PCD Temperatures

Figure 10. Reactor Flows

Figure 11. Outlet Gas Compositions

Figure 12. Startup Burner Propane Flow and Outlet Temperature

Figure 13. Reactor Mixing Zone Temperatures

Figure 14. Standpipe Differential Pressure/Reactor Pressure

Figure 15. Standpipe/Dipleg Temperatures

Figure 16. PCD Temperatures

Figure 17. Reactor Flows

Figure 18. Outlet Gas Compositions

Startup Burner Propane Flow and Outlet Temperature

11/8/96 00:00:00 AM

554.6048 2000

● FI364_COMP
90.68142
LB/HR
○ TI385
334.38574
degF

4-36

Figure 19. Startup Burner Propane Flow and Outlet Temperature

Figure 20. Reactor Mixing Zone Temperatures

Figure 21. Coal Feed Rate

Figure 22. Coal Feed Rate

Table 2. Coal Feed Rate

Starting Time	Ending Time	Coal Added, Lbs	Rate, Lb/Hr
11/16 0701	11/16 1636	1119	117
11/16 1636	11/17 0138	895	99
11/17 0138	11/17 1638	1944	130
11/17 1638	11/18 0108	3821	450
11/18 0108	11/18 15:38	7970	550
11/18 15:38	11/19 0040	5249	581
11/19 0040	11/19 1211	7283	633
11/19 1211	11/20 0012	7265	605
11/20 0012	11/20 0843	4197	493
11/20 0843	11/20 1640	4733	595
11/20 1640	11/21 0037	4824	607
11/21 0037	11/21 0740	4049	574
11/21 0740	11/21 1403	3430	537
11/21 1403	11/21 2250	6115	696
11/22 0520	11/22 1513	4804	486
Total		67698	

Table 3. Sand Additions For Run CCT2C

Time	Weight added
11/17 1800-1930	1249
11/18 0000-0800	2894
11/18 0800-1600	3599
11/18 1600-2400	0
11/19 0000-0800	2903
11/19 0800-1600	2511
11/19 1600-2400	1979
11/20 0000-0800	800
11/20 0800-1600	985
11/20 1600-2400	387
11/21 0000-0800	0
11/21 0800-1600	1350
11/21 1600-2400	111
Total	18768

4.2.2 Dolomite Rate

Dolomite was added only on 11/21/96 and 11/22/96. A total of 2441 pounds was added on 11/21/96 --1217 pounds between 0800 and 1600 and another 1224 pounds between 1600 and 2400. About 500 pounds was added after 1400 on 11/22/96.

5.0 PCD/ASH SAMPLING

5.1 PCD OPERATIONS

5.1.1 Westinghouse PCD/MWK

During the Fourth Quarter, there were four test runs totaling 465 hours of on-line operation. The most successful of the runs was the third, CCT2C (November 14-22), when the MWK Transport Reactor operated on coal for 146 hours. There were no significant problems with the PCD during any of the runs, in spite of particulate loadings well above design.

All of the tests in this quarter used sand instead of alumina as the Transport Reactor bed material. This change in bed material caused a dramatic shift in the mean particle size of the ash collected from the PCD hopper. For example, during the August run the mean particle size ranged from 5-15 μm . However, unless dolomite was being fed into the Transport Reactor, the mean particle size of the material leaving the PCD during the November run ranged from 50-320 μm .

Operationally, the focus was on reliably measuring the ash level in the PCD solids outlet cone using the existing thermocouples to avoid filling the PCD with ash. Using a combination of instrumentation from the PCD and ash removal system, the operations staff was successful in keeping the PCD cone essentially empty of solids throughout all four runs.

SRI successfully commissioned the inlet batch sampling probe during the November coal run. In total they took four samples which measured the bulk loading to the PCD. The results from their samples were comparable to the particulate loading as determined from the load cells on the ash removal system.

With the exception of two Schumacher F40 candle filters supplied by Roger Chen at WVU, all of the filter elements in the PCD are new elements manufactured by Pall. In the upper plenum there are 12 Pall 326 elements, 23 unused Pall 442T elements from Tidd and one of the Schumacher elements. In the bottom plenum there are 54 Pall 442T elements purchased by SCS and the other Schumacher element. No elements were removed for testing during the quarter.

5.1.1.1 CCT2A - October 2-17, 1996

Silica sand was used for the first time as a startup bed material in the Transport Reactor. During the run, samples taken from the PCD ash removal system had the appearance of coarse sand instead of the fine powder seen in previous runs. Lab analysis confirmed that the particle size distribution (PSD) of the material leaving the PCD was essentially the same as the material being fed into the Transport Reactor, approximately 200 μm . In addition to the large particle size, the carryover of particulate from the Transport Reactor was excessive and led to operational problems due to an inability to maintain reactor bed level. Finally, problems developed with the startup burner, so the test was terminated.

5.1.1.2 CCT2B - November 4-7, 1996

The startup of the test proceeded well, and the Transport Reactor team had made the transition to coke breeze when it was realized that the ash removal screw on the PCD had been tripped for a few hours. Solids feed to the Transport Reactor was tripped so that the PCD cone could be emptied, and Operations attempted to relight the startup burner. Unfortunately, the startup burner would not relight and the test was terminated.

5.1.1.3 CCT2C - November 14-22, 1996

The PCD operated for 146 hours on coal at an average temperature of 600°F. Throughout the run there was no indication of an excessive accumulation of solids in the PCD cone. There were several occasions when heavy carryover of solids into the PCD partially filled the cone. This was managed by changing process conditions within the Transport Reactor to minimize the carryover and allowing the PCD ash removal system to "catch up".

Southern Research Institute (SRI) commissioned their inlet sampling system during this test run by taking a total of four samples. The primary purpose of their testing was to "shake down" their sampling system and to provide bulk loading information. In general, the Transport Reactor operation was unstable during the sampling runs, however, there appears to be good agreement between the bulk loadings obtained by SRI's batch sampling system and the weigh cells from the ash removal system.

The PCD was visually inspected shortly after the run through the lower manway. There was no apparent bridging of ash between filter elements, and the filter elements were surprisingly clean. However, only the lower level of filter elements can be viewed from the lower manway. There was also no evidence of filter breakage and there was no ash accumulation in the PCD cone.

A detailed analysis of the run will be issued in a future commissioning report.

5.1.1.4 CCT3A - December 11-12, 1996

The purpose of CCT3 was to measure the efficiency of the disengager. The PCD was operated at relatively cool temperatures ($<340^{\circ}\text{F}$), and the primary purpose was to help gather information in support of the test. Overall, the test was fairly uneventful from a filter standpoint.

The PCD was again visually inspected from the lower manway after the run. There was no evidence of ash bridging, filter breakage or accumulation of ash in the PCD cone.

5.3 SPENT FINES REMOVAL

A brief equipment issues history sketch for spent fines removal in this reporting period is summarized below:

FD0520

- 11/17/96 The vent valve leaked a lot of gas. There is a 4.7 mm orifice down stream of the valve. The FD0530 bag house was running 5-10" of water. When inspected this valve was severely scored. FD0520 also had to be tapped to get the get flow of solids which may have been caused by a leaking vent valve. Also the spheri valve did not close within the delay timer time. This was later found to be due to a stuck shuttle valve.
- 12/4/96 A representative from Clyde Pneumatic Inc. came to study the problems we were having. He examined FD0520 and found that the shuttle valve, XV8537, was sticking. The piston was greased with O-ring grease. The other shuttle valves on the other feeders were also greased on FD0210, FD0220, FD0510 and FD0520 (2 per feeder).

5.4 PRELIMINARY DATA/EVALUATION

5.4.1 Conditions to Date

In the fourth quarter the PCD operated for a total of 465 hours as shown in Figure 23. Of those 465 hours, the PCD was filtering coal-derived ash for 146 hours.

Figure 23. Temperature vs. Operating Hours For 4th Quarter

Since operations began with the Westinghouse PCD in July 1996, the PCD has been in operation for 994 hours (Figure 24). Of those 994 hours, the PCD was filtering coal-derived ash for 226 hours.

Figure 24. Temperature vs. Operating Hours Since Start-Up

5.4.2 Test Run CCT2C

The only data and measurements on coal-fired combustion during this quarter came on this test run. The filter face velocity throughout the run was approximately 2 to 3 ft/min. Particulate carryover to the PCD ranged from 15,000 to 70,000 ppm, however, the mean particle size was still quite large (Figure 25). Even though the loading was high, the filter pressure drop remained remarkably low throughout the run (Figure 26).

The samples collected by SRI were taken to the lab for PSD analysis and compared to the samples removed from the PCD ash removal system. In general, the Transport Reactor operation was unstable during the sampling runs, however, there appears to be good agreement between the bulk loadings obtained by SRI's batch sampling system and the weigh cells from the ash removal system. The measured mass loadings obtained are shown in Table 4.

Figure 25.

PCD Differential Pressure and Face Velocity for November Coal Run

Figure 26.

Table 4. SRI Batch Probe Particulate Loadings

SRI Run No.	Date	Time	Mass Loading, ppmw
MWKIMT01	11/15/96	13:22-13:38	68,968
MWKIMT02	11/18/96	13:30-13:31	37,780
MWKIMT03	11/19/96	10:42-11:12	12,145
MWKIMT04	11/21/96	10:01-10:21	15,808

5.5 WESTINGHOUSE

Westinghouse ordered 40 Coors filter elements which should be available for the first gasification run. Also ordered were 300 gasket sets for standard Schumacher-type candles and 50 gasket sets for 3M type candles. The gaskets were received during the quarter and are being stored at Westinghouse.

5.6 COMBUSTION POWER COMPANY

Jan-Erik Overland from CPC visited the PSDF from 9/30-10/2 to work with construction on several fit-up and support problems. These were resolved and implemented prior to construction leaving the jobsite in October.

All of the refractory lined pipe, vessels, blowers and heat exchangers have been installed, as well as most of the small bore piping. No electrical/instrumentation work has been completed to date.

5.7 INDUSTRIAL FILTER AND PUMP

During the quarter, IF&P performed an in-house test to evaluate various adhesives which could be used to aid in filter assembly. Ideally, the adhesive would hold a gasket in place during installation, then volatilize at elevated temperatures to leave ceramic components "like new" and reusable without additional cleanup. A test report was completed and received by SCS.

5.8 SOUTHERN RESEARCH INSTITUTE

5.8.1 Batch Sampling System

Cold shakedown of the inlet sampling system was successfully completed in October. As previously mentioned, the hot shakedown was completed during test run CCT2C in November. Some very minor problems were encountered and overcome during the test run.

The samples were collected in the bulk sampler that has been described in previous reports. The sampler provides two particle-size fractions: a precollector cut containing particles larger than 12 μm (nominally) and a filter cut containing all smaller particles. The high particulate loadings experienced during sampling tended to overload the precollector, resulting in the presence of large particles in the filter catch. This carryover did not have any effect on the mass loading measurements obtained.

5.8.2 Cyclone Manifolds

SRI has gathered together all of the components for two conventional, stainless steel cyclone assemblies and two titanium assemblies. An adapter flange for mounting the assemblies on the sampling probe was designed and fabricated.

The second manifold casting was received in November. X-rays revealed no voids in the receptacle portion of the manifold, but several pin holes were found in the bauxite canister dome. Howmet has agreed to repair the holes or produce another casting at no additional cost.

5.8.3 Ash Lab

SRI and SCS are working to develop an on-site laboratory for ash characterization. During the quarter, purchase orders were released for a helium pycnometer to measure true ash density and for a BET apparatus to measure specific surface area. Currently, the PSDF has the capability to perform the following ash analyses: particle size distribution (sieve and Microtrax), ash chemistry, true particle density, cake porosity, bulk density and specific surface area. In the upcoming quarter an apparatus for measuring dust cake permeability will be designed and built.

6.0 AUXILIARIES AND BALANCE OF PLANT

6.1 FEEDSTOCK PREPARATION

The Balance of Plant transporters (FD0104, coal, FD0154, sorbent, and FD0140, coke breeze and other solids) have functioned well. FD0140 did plug but the plugging was due to wet solids.

6.2 PROCESS AIR

The Main Air Compressor experienced some control problems during test run CCT2C and CCT3A. On two consecutive nights during CCT2C, the compressor started to surge and then automatically unloaded tripping several other systems. At this time we were also experiencing problems with the Transport Air Dryer which was causing some pressure swings (~60 psig) in the compressor downstream pressure. However, the compressor continued to have control problems during CCT3A, the disengager efficiency tests, in December after the dryer had been repaired. Atlas Copco informed us that since the compressor tuning parameters were set in the summer for "summer air" (humidity ~90% and temperature ~90 °F), the compressor must be tuned again for the current conditions (humidity ~40% and temperature ~40°F). Atlas Copco will be on site in January to tune the compressor and to perform preventive maintenance on the compressor. Figure 27 is a graph of discharge pressure, inlet guide vane position, and blowoff valve position showing a compressor unload during CCT2C.

Figure 27. Main Air Compressor Valve Position and Discharge Pressure

6.3 TRANSPORT AIR

On November 16, 1996, during CCT2C, it was noticed that the Transport Air Dryer Tower 1 was repressurizing rapidly because the regeneration blowoff valve, XV8116, was not closing and that the purge flow meter was not maintaining its setpoint. The dryer was taken out of service and all the valves (XV8116, XV8117, XV8118, and XV8119) were taken apart and cleaned. Since the tower had been repressurizing so rapidly there was a chance that some of the desiccant could have been blown out. So, the afterfilter was inspected and only a small amount of desiccant was found in the bottom and the filter cartridge was relatively clean. The afterfilter cartridge and the orifice purge flow meter were removed and blown clean. When the dryer was placed back in service, Tower 1 repressurized slowly and the purge rate flow maintained its setpoint. Also during this run, the prefilter was draining much more water than in the previous runs indicating that there could be a problem with the upstream separator. The separator will be inspected during the outage in the next quarter.

6.5 PROCESS GAS SAMPLING

The GC is fully calibrated and tuned and is ready for operation. The autocalibration setup was tested and a few wiring problems were corrected. The GC signal wires for the H₂ and N₂ indications were crossed.

The range of the CO Process Gas Analyzer (AIT-435) was changed from 0-25% range to 0-50,000 ppm (0-5%) range. The CO analyzer was zeroed with N₂ and spanned with 40,000 ppm (4%) CO gas. A bottle of 9,900 ppm (.99%) CO was used to check the low end for linearity. The low end linearity was good. However, with instrument air running through the CO analyzer at this time, there is a lot of noise. The CO analyzer should only be used when the CO concentration is 10,000 ppm (1%) or greater.

6.6 THERMAL OXIDIZER

The thermal oxidizer operated well during the last quarter of 1996 with only a few minor instrumentation problems. On Tuesday, December 4th after test run CCT2C, an inspection of the Thermal Oxidizer refractory was completed. The cracks in the refractory were not noticeably larger than they were during the previous inspection (July 1996); however, there was some small spalling about 1 inch long and 1/4 inch deep. Some larger refractory pieces were found in the bottom of the vessel which were believed to come from the top of the vessel; thus, a more in-depth inspection of the top section was conducted on December 19, 1996. This inspection revealed some flaking and minor cracks less than 1/8 inch deep in the upper section, but no large cracks were found. Overall the refractory was in good condition and does not need any repair at this time.

6.7 STEAM/CONDENSATE

Due to low coal feed rates during all commissioning runs, the steam and condensate system operated below design conditions causing some problems. There was a persistent water hammer in the boiler feed water (BFW) line, because the BFW temperature did not reach its setpoint and because the BFW was introduced into the vapor space of the drum. To solve this problem and the drum level control problems, a line will be installed which will introduce the BFW into the drum via a chemical injection line below the water level. Low steam production also caused problems with supplying sufficient steam to the propane vaporizer. To address this, a different operating philosophy concerning the drum pressure was implemented. The drum operating pressure was reduced, and the Thermal Oxidizer was fired higher so that the drum pressure could be maintained with the steam pressure control valve operating around 40% open to supply sufficient steam to the vaporizer. Figures 28 and 29 illustrate the operations.

Figure 28. Steam System Operations August 5, 1996

Figure 29. Steam System Operations November 21, 1996

6.8 SULFATOR

The Sulfator Air Compressor (CO0601) was started for the first time and test run. No problems were found with CO0601. A positioner was added to the vent valve (FV620) in order to give better flow control of the process air to the sulfator.

Problems with the propane vaporizer, propane piping heat tracing, and trash in the Sulfator Startup Heater's (BR0602) propane pressure regulator all contributed to difficulties in the joint refractory cureout attempt of the Sulfator system. The propane flowrate would decrease at times and trip BR0602. At other times, the flow reading fluctuated wildly and BR0602 would continue to operate. The RTD controlling the propane line heat tracing was replaced and the BR0602 regulator was cleaned. All of the propane flow problems, associated with BR0602, were resolved.

A new pressure regulator was installed in the propane line going to BR0602. Since the propane pressure in the structure had to be increased to 190 psig for the reactor burner, the regulator was required to bring the propane pressure in the line going to BR0602 to the design pressure of 85 psig.

BR0602 relies heavily on radiation as the mode of heat transfer to the process air. Multiple difficulties were encountered while trying to achieve the process design conditions. Calculations showed too much excess air going into the naturally drafted BR0602. Also the draft was high. A draft gauge was installed and a hand held O₂ sensor was used to measure the O₂ level.

After the draft and the O₂ levels were corrected, the design process outlet temperature was reached; however, the mass flow rate was about 14% below the design of 6200 lbs/hr. The problem was compounded since the BR0602 process air inlet temperature was 70°F below design.

The Sulfator vessel did not reach the temperature required for the joint refractory cureout. This was not a surprise, since the Sulfator vessel was empty. The cureout will have to be completed when solids are placed in the Sulfator vessel and the heat transfer is increased or may even have to be done when the Sulfator is placed in operation.

The Sulfator Startup Heater (BR0602) was shut down for inspection in November when flame was seen below the burner cone. The burner gas tip was found to be covered with carbon which may have resulted from the burner being fired at a low heat release for an extended period. The gas tip threaded connection was found to be leaking which explained the visible flame below the diffuser cone. The gas tip was cleaned and the threaded connection was redone. The inside of the heater was inspected and four of the approximately sixty u-bolts that hold the process piping were found broken. The u-bolts will be replaced by the heater vendor and the broken u-bolts will be sent to the vendor for inspection. According to the Heater manufacturer, breakage of these u-bolts is common and not of concern.

A brief historical issues sketch for solid transport equipment associated with the Sulfator system is summarized below:

FD0810

9/96 Functional checks were written for FD0810 (sulfator ash to the ash silo) and completed 11/11. FD0810 transporter for the sulfator solids has not been put in service.

FD0610

9/96 Functional checks were written for FD0610 (limestone/sorbent to the sulfator) and completed.

FD0602

9/96 Functional check were written for FD0602 (screw cooler on sulfator ash to FD0810) and completed 10/31.

6.13 PROPANE

The pressure relief valve on the propane vaporizer was leaking at 178 psig. The leakage stopped when the propane pressure was reduced to 167 psig. A new relief valve was installed.

6.14 INSTRUMENT AIR

The pilot operated drain valves for the instrument air dryers were problematic. Water was getting inside of the pilot valve and was creating problems with the seals. To remedy the problem, the air for the pilot line was changed from the inlet side of the dryer (i.e., the "wet side") to the outlet side (i.e., the "dry side") on all five of the instrument air dryers. All of the drain valves were disassembled and cleaned.

6.16 WASTE WATER TREATMENT AND CHEMICAL INJECTION

Two minor pump problems occurred with the chemical injection system. The pump injecting trisodium phosphate pump at the steam drum and the pump feeding sulfuric acid to the cooling tower failed. Both situations have been resolved and spare pumps have been ordered and delivered.

6.17 AUXILIARY BOILER

The Auxiliary Boiler was readied for testing and start-up. Control circuits were tested, the feedwater pumps were run for vibration monitoring and the piping was pressure tested during the last week of the quarter.

7.0 SUPPORT SERVICES

7.1 OPERATIONS AND MAINTENANCE

Work is finished in preparing a work order system database, and continues in filing equipment maintenance information for reference, procedures and spare part requirements. The automated Work Order Management System was put into service in November, and used to identify work for all departments at the site. A CPM schedule of all the outage activities was developed, and will act as a basis for planning future outage work scopes and for developing test plan schedules and turn-around timelines. The growing database of recommended spares is being expanded as vendor documentation arrives and orders are being generated from that database using commonality, experience and judgment as guides.

The FW designed refractory-lined vessels that required cure-out of the refractory, were prepared for storage and weatherized for the winter. The remainder of the FW equipment was also prepared for long-term storage by connecting the motor heaters, covering equipment, and setting up both the Booster Compressor and the Transport Air Compressor for temporary operation to exercise the machinery.

7.1.1 Maintenance Inspection and Procedures

As pumps and compressors were started, vibration readings were taken to define the initial operational state of each machine and to provide a baseline set of data for future comparisons. To date, baseline vibration readings have been taken on 45 pieces of equipment (pumps, compressors, fans, blowers). All of this information is stored in a database that is used for trending and data analysis.

Monitoring and inspection of equipment continued. Inspections utilizing the inspectorscope (borescope) continued; the condition of the refractory lining inside the reactor start-up burner and also the condition of the pilot and main burner tips were recorded on video. The videotapes will be used for comparison after the burner has been operated for a period of time to determine the degradation.

The infrared camera was used to scan the thermal oxidizer, waste heat boiler, Transport Reactor and Start-Up burner to verify uniform heat distribution on the outer surfaces. This was done on all heated vessels/piping as start-up progressed to provide a baseline database, and will continue to be done during operation to monitor for insulation degradation.

Baseline thickness measurements continued using the ultrasonic thickness gauge on elbows/tees (excluding Basalt lined fittings) in the ash transport systems. These readings have been taken on all pneumatic conveying elbows/tees to establish a baseline database.

7.2 LABORATORY

The lab staff was engaged in routine analytical work in support of the PSDF operation of the MWK reactor train. During the fourth quarter 306 samples were logged into the PSDF laboratory. These included the following: 52 PCD solids samples; 35 MWK reactor solids samples; 35 MWK ash silo samples; 5 PCD inlet samples (from the SRI sampling train); 12 coal samples; 6 raw water samples; 73 cooling tower water samples; 4 cooling tower blowdown samples; 1 condensate tank water sample; 14 MWK circulating cooling water samples; 29 SCS circulating cooling water samples; 16 boiler condensate samples; 2 wastewater treatment plant effluent samples; 3 wastewater samples; 3 thermal oxidizer burner samples; and 16 miscellaneous samples (ash, sand, UCONN heat transfer fluid, etc.).

Nine of these samples were submitted to the off-site laboratory for analysis. The remainder were analyzed in the PSDF laboratory. The off-site lab performed ash minerals analyses, coal proximate and ultimate analyses, polyaromatic hydrocarbons analyses, TCLP metals analyses, wear metals analyses, and trace metals analyses. Cooling water analyses, sieve analyses, Microtrac particle size analyses, as-received loss-on-ignition analyses, and bulk density analyses were performed by the PSDF lab staff. In most cases, several analyses were performed on each sample.

The Labworks Laboratory Information Management System (LIMS) that was purchased from Analytical Automation Specialists, Inc., is fully functional and is being used to track all samples that are submitted to the laboratory for analysis. Samples are assigned a laboratory identification number when they are logged onto the LIMS and the LIMS system tracks the progress of each sample as it progresses through the laboratory. These steps routinely include log-in, results entry, validation, and reporting. The capability of the system to include identifying information and comments along with the analysis results is being fully utilized. The method that is in place to electronically transfer data from the off-site laboratory is also fully functional. This method currently involves the transfer of data via email as attached ASCII files. This data is collated and imported into the PSDF LIMS using software supplied by Analytical Automation Systems, Inc.

7.3 DATA MANAGEMENT

The Plant Information (PI) system was upgraded to version 3.1. This new version supports point-by-point security, which is being implemented in stages. Also, all users have been upgraded to the 1.3 version of PI-Process Book and the 1.6 version of PI-Datalink. The system has been operating near flawlessly since the upgrade.

7.4 ENVIRONMENTAL

During the time interval that the facility was operating on coal, an air compliance test was not performed due to the unsettled nature of the process. The Alabama Department of Environmental Management (ADEM) Air Division has been kept informed on progress regarding the air compliance testing. A Fourth Quarter Air Emission Summary Report was filed with ADEM and a Fourth Quarter NPDES Wastewater Discharge Monitoring Report was submitted to the Industrial Water Section of ADEM. On October 22, the annual NPDES Stormwater Discharge Report was submitted to ADEM. During the time interval that the process was on coal, some ash material was generated. Two loads of ash were transported to the landfill during this quarter. The waste contained a significant portion of silica products not only from the ash but also from some of the circulation tests that were being performed. Overall, the ash loading process worked satisfactorily.

7.5 SAFETY

Personnel from the PSDF attended a scaffold safety training session presented by the Scaffold Training Institute on December 18 at the headquarters location of Alabama Power Company. The Confined Space Rescue Team participated in a training session with personnel from Plant E.C. Gaston and these teams continue to work together in this area. On October 1, the Safety Officer and two personnel from the warehouse attended a two-day course on Hazardous Material Management in Birmingham, Alabama. The course covered many aspects of the Department of Transportation (DOT) requirements for shipping and receiving hazardous materials. There were no OSHA recordable injuries for this quarter. Through 1996, there were a total of three OSHA recordable injuries involving SCS and Alabama Power Company personnel. None of the injuries involved lost time away from work.

8.0 PROJECT MANAGEMENT

The Cooperative Agreement for the Power Systems Development Facility, DE-FC21-90MC25140, between Southern Company Services and the United States Department of Energy is currently scheduled to expire on March 13, 1997, which is the end of Budget Period 5. SCS prepared and submitted a Request for Contract Renewal (RCR) for this Cooperative Agreement to the Department of Energy on September 30, 1996. DOE reviewed the RCR and sent review questions to SCS. SCS has responded back to DOE with answers to these questions. Negotiations to finalize renewal of the contract are currently underway. The RCR covers annual Budget Periods #6 through #10. The scope of Budget Periods #6 and #7 will include the following: (1) completion of the construction phase of the Advanced Pressurized Fluidized Bed Combustion Module (APFBC) which includes Foster Wheeler's technology for second generation Pressurized Fluidized Bed Combustion (PFBC), associated Particulate Control Devices (PCDs), the Compressor/Turbine Module, related Balance of Plant facilities, and the operation and testing of these modules; and (2) the continued operation and testing of the Advanced Gasifier Module which involves M.W. Kellogg's transport reactor, associated Particulate Control Devices and related Balance of Plant facilities. Budget Periods #7 through #10 will cover the operation and testing of these modules plus the operation and testing of the Fuel Cell Module.

A project review meeting to discuss status and future plans was held with DOE at the Wilsonville site on October 22 and 23. The major meetings held at PSDF during this quarter are summarized in Table 5.

Table 5. Roster Of PSDF Meetings

Date	Group	Purpose
9/27/96	Nguyen Dung (zoong) CSIRO Division of Coal and Energy Technology Australia	Identify opportunities for CSIRO to do research.
10/04/96	DOE Japanese Visitors	PSDF Site Visit
10/15/96	Central Alabama - AIChE	Monthly Meeting/Tour PSDF
10/22/96	Southern Company I&C Technical Group	Southern Company I&C Technical Network Meeting
10/22/96 - 10/23/96	DOE Project Review Meeting	PSDF Status
11/12/96 - 11/14/96	PSDF Technical/Operations	PSDF Lessons Learned During Construction, Completion and Commissioning
11/15/96	Clyde Pneumatics	Startup Discussions/Negotiations
11/18/96	PSDF Labor Broker Bidders	Labor Broker Pre-Bid Meeting
11/18/96	PSDF Erection Contractor Bidders	Erection Contractor Pre-Bid Meeting
11/20/96 - 11/21/96	1996 Southern Company Technical Managers	Semi-Annual Plant Technical Managers Meeting
12/03/96	Stamet	Discuss Testing on Stamet Dry Coal Pump At PSDF
12/03/96	SCS R&EA Advanced End-Use Technologies (AEUT)	AEUT Staff Meeting/PSDF Overview

9.0 FUTURE PLANS

During the outage at the end of 1996 and early 1997, modifications to the Reactor Start-Up burner, the Combustion Heat Exchanger J-leg, the Steam Drum make-up line, and the Cyclone should be completed. Inspections of the Dense Phase Systems, the Process Air Compressor, and various BOP systems should find and prevent impending failures. During the outage, project staff will be trained on the changes in either philosophy or installation of all plant equipment. Such training will help ensure that personnel are up to date with procedures and proper operation of the Project's developmental process components, preventing operator failures or spurious control trips. After the outage is complete, another combustion test run with the MWK transport reactor system is planned to start in March of 1997. After this combustion run, there will be a brief outage for assessment of status followed by another combustion run. After this second combustion test period, the facility will experience a major outage (second quarter of 1997) to prepare for the first gasification run.

General Electric Environmental Systems, Inc. (GEESI) will be providing assistance to resolve the problem with excessive solid carryover from the cyclone to the PCD. GEESI will assist in evaluating the results of the disengager efficiency test (CCT3A) and in performing their own in-house tests. During the next quarter recommendations will be forthcoming and implementation of any recommended modification should commence.

Regarding Foster-Wheeler, during the next quarter the bids received in December from the Request for Quotation (released for the erection and construction of the remaining Foster-Wheeler and related BOP equipment) will be evaluated in conjunction with labor broker bids for construction support. Selections should be made and contract negotiations should also begin in the next quarter. The most likely start date for construction is during the month of May.

Plans for the PCD area during the first quarter of 1997 are as follows:

- An orifice will be installed in the Primary Gas Cooler Bypass to raise the inlet gas temperature of the PCD to approximately 1200°F for the next combustion run.
- SRI will complete the required modifications to the conventional stainless steel cyclone assembly in time for the next combustion run to allow for in-situ size segregated sampling.
- SRI will complete and commission the outlet sampling probe. Initial tests will be with the batch sampler, with some testing using the cyclone assembly. The cascading impactor fabrication should be complete in the first quarter.
- Acoustic detectors will be ordered.
- The BET apparatus should arrive for the ash lab. The filter cake permeability tester will be designed and fabricated.
- The filter element permeability tester will be designed.

- 3M and Schumacher candles will be ordered. The Coors elements from Westinghouse will be shipped to the PSDF.